39 Experiments in Soils

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39 EXPERIMENTS IN SOILS

by

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FOR THE TEACHER.

By most authorities Agriculture is divided into six divisions. These divisions are merely for convenience and vary in detail in different localities, but under all conditions the subject of soils is considered one of the most important classes.

It is agreed by educators that no class, as a rule, should take up more than one of the six subjects in a single school year. It should always be remembered that NO MORE SHOULD BE ATTEMPTED THAN CAN BE DONE WELL. For example, if soils is the subject selected for the class it should be pursued throughout the entire year, unless a great deal of time is given to the subject each day. Soils should be the first subject studied by beginners, for from the standpoint of psychology all Agriculture must begin with soils. All plant life is dependent upon soil for its growth, and all animal life in turn depends upon plant growth.

In accordance with the above facts the following experiments have been compiled for beginners in Agriculture. These experiments are simple, yet they are practical. They can be performed with very little apparatus, and most of this can be made by the student at practically no expense. The results of all of the following experiments should be written on the page opposite the experiment. Teachers should demand that this work be done in pen and ink and that the notes be kept up to date. Supplementary experiments should be performed and the results written on the blank pages, so that when completed the book becomes a complete manual of the school work. If properly performed, the experiments are the most important part of a course in Agriculture. A mere mass of facts committed to memory is not the sort of agricultural knowledge that the school demands, or needs.

Each student should be given an opportunity for doing things rather than for seeing or hearing how they are done. All experiments should, as nearly as possible, be carried on in connection with the regular farm work. If this is done many questions will arise which will furnish the basis for the kind of discussion that is real Agriculture.

A text-book should always be used in connection with a course in Agriculture, but it should serve more as an outline or guide, rather than a source of information.

Thirty-Nine Experiments in Soils is a guide to practical Agriculture if properly taught. See to it that the blank pages are not merely filled with copied ideas, but with really worth while conclusions, logically arrived at by the student himself.

EXPERIMENT 1.

THE EFFECT OF HEAT UPON PLANT GROWTH.

Object. Different kinds of plants grow from the cold regions of the North to the Torrid zones of the Equator. Some of these plants require only a very little heat to grow, while others require a great deal, but heat in some amount they all must have. Without some heat no plant could even germinate. Therefore, we may say that heat is a condition that is necessary for all plant life. The following experiment shows this very nicely.

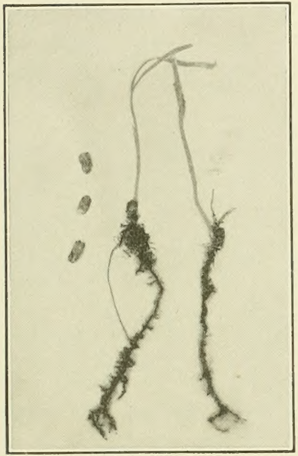

FIG. 1
At Left—Seeds decayed for want of heat.
At Right—Seeds gone to produce a plant.

Apparatus. Two tin cans or flower pots, twelve corn kernels or beans, sand and water.

Procedure. Fill the flower pots or tin cans with clean fine sand. If tin cans are used, take a large nail and punch holes in the bottom of each can. In each vessel plant five large, healthy seeds. Either corn or beans will be suitable seeds to plant. In order that all of the seeds will have an even chance to grow, be sure to plant them at exactly the same depth. Water both pots liberally. Place one pot of seeds in a warm place and the other in a very cool place. Examine both at the end of a week. Dig up the seeds that were in the cold soil. 1. What has happened to them? 2. What happens when a farmer plants his seed before the ground is warm? 3. What has become of the seeds that were planted in the warm soil? 4. Do you see any advantage in planting large seeds? Write the result of your experiment on the opposite page and make a drawing to show it.

EXPERIMENT 2.

THE EFFECT OF LIGHT UPON PLANT GROWTH.

Object. Although we cannot control the sunlight, the study of its value is of importance to us. Plants manufacture food and they do this only in the presence of light. They unite the carbon dioxide of the air with the water obtained through the roots, into a new substance, known as starches and sugars, called also carbohydrates. Man cannot do this, nor does he understand how it is done. We know, however, that the green coloring matter of the leaves called chlorophyll does this work in the presence of sunlight. Without the light plants die of starvation. Perform the following experiment to show this:

Apparatus. Two tin cans or flower pots, ten or twelve beans, soil, water, and a box that is light tight.

Procedure. Start some beans to grow in each of two receptacles. After they are up nicely place the light tight box over one pot of plants in such a manner as to exclude all of the light. At the end of a week, remove the box and compare the plants left in the light with the ones kept under the box. Explain what happens when a plant cannot get sufficient light. Can a farmer plant his crops too thick? Can he in any way control the amount of light each plant receives?

Another interesting way to show the effect of light upon plant growth is as follows: After a potato is well started in a pot of soil, cover it with a joint of stove pipe. Over the top of the stove pipe put a piece of cardboard having a hole in it the size of a dime. Place the experiment in a warm, fairly light place and observe from time to time. Explain what happens. What color does the potato stem become? Suppose a potato vine in the garden was surrounded by tall weeds. What effect would they have on the potato plant?

On the opposite page write a discussion of the importance of light upon plant growth. Make a drawing to show the results of your experiment.

EXPERIMENT 3.

THE EFFECT OF MOISTURE UPON PLANT GROWTH.

Object. Plants are very sensitive to moisture and it is essential at all times for their growth. It requires about 300 pounds of water to produce one pound of corn plant. This water must be had on the driest days of summer as well as during the wet spring days. When a farmer has learned to keep this water supply fairly constant, by proper ditching and soil mulching, he will have gone a long way toward increasing his crops.

The following experiment shows the effect of moisture in varying amounts, upon plants:

Apparatus. Some soil, three flower pots or tin cans and ten or fifteen corn kernels, or beans.

Procedure. Plant some seeds in each of the three receptacles, and water each receptacle alike. After the plants are up, treat them as follows: Do not water one pot at all; give another only a small amount of water, and give the third enough water to keep the soil completely saturated. Examine the plants often and note any differences they may show. What effect does too much moisture have on the growth of plants? On a farm, how may we get rid of an oversupply of moisture? Write on the opposite page the results of your experiment. Make a drawing to show each pot of plants, and by the side of each write the total amount of water supplied to that pot.

If you have time, sprout a potato in a pot of clean sand and after it is up three or four inches, cease watering it any more than is absolutely necessary. If carefully performed, you can get the potato plant to live for several months with very little water, and since it grows in sand it must have very little food. This shows under what variable conditions plants are able to live if it becomes necessary.

EXPERIMENT 4.

MINERAL SUBSTANCES AND ORGANIC SUBSTANCES.

Object. All substances are classified as belonging either to the animal, the vegetable, or the mineral kingdom. Substances belonging to the animal and vegetable kingdoms are said to be organic; that is, they are organized substances that have or have had life. This includes all substances except the inert rock and chemical materials found as a part of the soil. Mineral substances are the inert, lifeless rock particles that do not enter into organized tissue. Any plant or animal contains some mineral matter. It is a very easy matter to divide a substance into its mineral and organic parts. All organic material under proper treatment will pass into the air from whence it came.

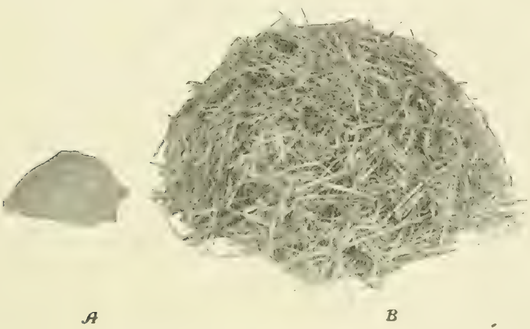

FIG. 2
A. Mineral Matter Left After Burning.
B. Mineral and Organic Matter in the Form of Straw.

Apparatus. Potato, some source of heat, as a stove, or alcohol lamp; a pair of balances, and a pan.

Procedure. Wash the potato clean. When dry, weigh it accurately. Record the weight. Then burn in an oven or over a flame until all that will burn has been removed. Weigh that which remains and record the weight. That which remains is called plant ash, or mineral matter, and has come unchanged from the soil. Figure out what per cent. of the potato came from the mineral matter of the soil. What part came directly and indirectly from the air?

Perform the same experiment with other substances, as tomatoes, meat, cucumbers, milk, etc. Record all results in the form on the opposite page.

EXPERIMENT 4

Name.. Date..

MINERAL SUBSTANCE AND ORGANIC SUBSTANCE

Name of Substance	Entire Weight	Weight After Burning	Percentage of Organic Matter	Percentage of Mineral Matter
* Average percentage of each				

*This will give you a fairly good understanding of the average relation between the amount of organic and mineral matter in most plants.

REMARKS:

EXPERIMENT 5.

TO SHOW THAT THE ROOTS OF A PLANT GIVE OFF ACID.

Object. We have found in recent years that after a field has been cropped for a number of seasons, it changes for two reasons: First, on account of the plant food which the crops remove, and, second, on account of new substances which the plants leave in the soil. Among the new substances left by plants there are acids which, if left in the soil, become harmful and in time make the soil unproductive. It was first thought that only decaying plants gave off this acid, but it has lately been shown that living plants excrete acids from their roots. To prove that growing plants do give off acid, the following experiment has been devised. If carefully performed it will give striking proof of the fact above stated.

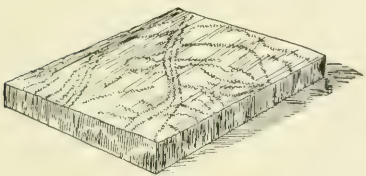

FIG. 3.
This shows how the roots of a plant have attacked a piece of solid marble.

Apparatus. A piece of smooth stone, such as marble, or a boulder having a smooth, flat surface; a few seeds, as corn or clover; soil and a flower pot or tin can.

Procedure. Germinate a seed, such as a corn kernel, in a pot of sand, and as soon as the little plant is above ground dig it up carefully so as not to injure the little rootlets. Lay the roots of this plant against the smooth side of the stone which you have selected. Cover the roots with soil and let the plant grow for about three weeks.

At the end of that time, *remove the stone,* and wash it clean. See if you can find where the roots came in contact with the rock. What does the outline of the roots on the rock show you? Can you in any way compare the secretions of the stomach of a man with the excretions of the roots of a plant?

EXPERIMENT 6.

TO SHOW THAT WATER DISSOLVES MINERAL MATTER.

Object. All mineral plant foods must be dissolved by water before they can be taken into a plant as food. The water carries the plant food to its destination in the plant. No difference how much plant food there is present in a soil, unless it is soluble in water it is worthless to the plant. We ofttimes find that a soil by analysis shows enough plant food to produce good crops, yet the crops fail, because they cannot get this plant food, which is present. We can compare the productiveness of various soils by allowing plants to grow in the water which has soaked through these soils. To show how this may be done, grow plants in two samples of water, as follows:

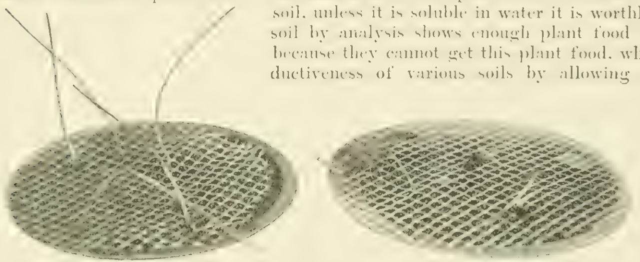

FIG. 4
A. Plants Grown in Soil Water. B. Plants Grown in Rain Water.

Apparatus. Soil water (from the well) and pure water (either distilled or rain water caught directly in a clean vessel); two shallow pans; two pieces of screen wire of the same size as the pans; wheat kernels, and pot of sand.

Procedure. Obtain a half-gallon of pure water as above explained, and keep it closed in order that no impurities can get into it. Take some wheat kernels and plant them in the pot of sand. After they have grown an inch or so above the surface, carefully dig them up. Take the two pieces of screen wire and carefully push the roots of five plants through the meshes of each piece of screen wire so that the seed kernels rest on the screen.

Put one piece of wire in each pan and pour distilled water in one and soil water in the other. Pour in just enough water to cover the roots and the seed kernels. Keep the water in the pans as near a constant level as you can by adding water from time to time. Always use the same kind of water in the same pan. It is best to label one pan so there will be no confusion.

At the end of a week write on the opposite page any results that you may observe. If there is no apparent difference and both samples are growing, leave them until results appear. What did the soil water contain which the rain water did not have? Why is water called the blood of the plant? Soak samples of different soils in water for a week. Pour off the clear water and grow plants in each. What difference do they show as regards growth? This experiment is very practical; it can be made as elaborate as the time permits.

EXPERIMENT 7.

DIFFERENCE IN SOILS DEMONSTRATED.

Object. The mechanical condition of a soil is a very important guide to its fertility. If a soil breaks up well when plowed, does not easily bake, or puddle, and absorbs water in sufficient amounts, it is usually a good soil. These conditions, in a large measure, depend upon the texture of the soil, its porosity and the amount of organic matter present. Let us see if we can judge by an examination of a sample of soil in just what degree these conditions are present.

Apparatus. Three small jars or bottles which can be sealed tightly, a ruler, a pair of balances, an iron spoon and a soil auger, or, if this is not to be had, a trowel and spade will answer.

Procedure. Go to the field that you desire to test and get three soil samples as follows: Scrape away the plants and surface soil to about an inch depth. Take a sample of the soil just below this and seal it air-tight in one of the jars. This is to prevent the escape of any moisture that may be present in the soil. Likewise, dig or bore down to a depth of six inches and take another sample of soil. Secure a final sample at a depth of twelve inches from the surface.

As soon as possible after returning to the school-room, weigh out equal amounts of each soil—say, four ounces. Spread each sample in a shallow pan and let it dry for two days or more. Weigh each sample at the end of this time. The difference between these weights and the first ones is the amount of water which each soil contained that could be removed by evaporation. Next note carefully the color of each sample of soil. Examine to determine the size of the soil grains. Use a magnifying glass for this if you have one. Grind the particles in the palm of the hand. The gritty, hard feeling denotes silt; the fine, powdery feeling denotes clay. Heat each sample in an iron spoon until everything that will burn has been burned. Weigh each one again. The difference between these weights and the previous ones shows approximately the amount of organic matter in each. The final weights show the amount of mineral matter which each soil contains. Write the results of this experiment on the opposite page. Carefully fill out the form furnished and explain the differences apparent between the same soil at different depths.

Repeat this experiment, using samples from other fields.

EXPERIMENT 7

Name .... Date ....

DIFFERENCE IN SOILS DEMONSTRATED

Depth of Soil	Color	Amount of Moisture	Amount of Organic Matter	Size of Soil Grains	Name of Soil
1 inch					
6 inches					
12 inches					
1 inch					
6 inches					
12 inches					

REMARKS:

EXPERIMENT 8.

TEMPERATURE OF LIGHT AND DARK SOILS.

Object. When a farmer says that he has a good rich soil, we usually think of it being a black soil. As a rule, a black soil is considered a rich soil without any investigation. One of the reasons a black soil is rich is on account of the heat it absorbs. This heat causes it to warm up early in the spring and causes plants to grow more rapidly during the entire summer.

At first thought it would seem that a black soil and a light soil, subjected to the same conditions, would be equally heated. However, a black soil will more readily become heated, as the following experiment will prove:

Apparatus. Clay, muck, lime, four shallow pans and four thermometers.

Procedure. In three of the pans put enough air-dry clay to fill them about two-thirds full. Put into the fourth an equal amount of water that has been standing in the room for some time. Spread a layer of muck over the clay in the first pan sufficient to fill the pan. In a like manner, cover the second pan with powdered lime. Leave the third and fourth as they are.

Now put a thermometer into each pan, being sure that the bulb of the thermometer is covered with the substance in that pan. Place the pans in the sunlight and read the thermometers every fifteen minutes for an hour or two. Do not remove the thermometers to read them, and be sure to read them accurately.

What differences do you note in the temperatures? What does this show you about light colored soils? How might a farmer influence the color of his soils? Would a farmer desire to have his soil warmer or colder? Why? Is there enough difference in the temperature of soils due to color to influence the kind of crop planted on the land?

If possible, instead of using soil samples, go out into the field and take the temperature of light and dark soils at regular intervals for a day.

EXPERIMENT 8

Name .... Date ....

TEMPERATURE OF LIGHT AND DARK SOILS

Pan contains	Temperature at Beginning	Temperature at end of 15 Minutes	Temperature at end of 30 Minutes	Temperature at end of 45 Minutes	Temperature at end of 60 Minutes	Temperature at end of 75 Minutes	Temperature at end of 90 Minutes	Average Temperature
Clay and Muck								
Clay and Lime								
Clay								
Water								

REMARKS:

EXPERIMENT 9.

WHY A SOIL BECOMES CLODDY.

Object. The chief reason that a soil becomes cloddy is because it is cultivated when it is not in the proper mechanical condition. Usually, when a field is cloddy, it has been plowed too wet. Sometimes, however, a field is cloddy because it has been plowed too dry. When the field is plowed too wet, the soil grains move over one another and get as close together as possible. Then when the moisture leaves, the soil is hard and lumpy. It is said to be puddled. When a field is very dry the soil grains cannot move past each other when plowed, and consequently the soil turns over cloddy. If you will draw straight lines across the edge of your book at regular intervals and then bend the book, you will see a movement which illustrates what happens to pulverize the soil when it is plowed. This cannot happen when the soil is either too wet or too dry.

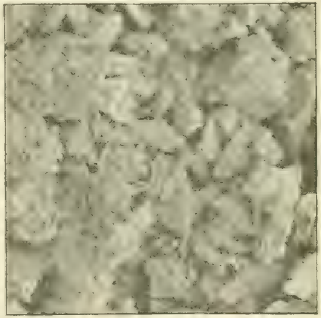

FIG. 5
Puddled Soil.

Apparatus. A number of small pans, a stirring rod, and samples of different types of soils.

Procedure. Take a sample of each kind of soil obtained and place it in a pan. Cover each soil with water and stir until the water and soil are thoroughly mixed. Use as nearly equal amounts of soil as you can and pour over each the same amount of water. Set the pans away to dry. Which kind of soil dries first? Why? After they are all dry, examine them. Which one is the hardest? Which one is the softest? Why? What happens when we plow wet? Do you think that it pays to start the plow a little early in order to gain a few days of time?

How would you go about it to tell when a soil is too wet to plow?

Write all results on the opposite page.

EXPERIMENT 10.

PLANNING A ROTATION.

Object. A plant has a very hard time in its growth under the best of conditions, and we certainly cannot expect much when we carelessly make these conditions worse. In the spring, as a rule, a plant does not have enough heat, but it usually has too much moisture, and later in the summer enough heat but a scant supply of moisture. Each plant, in adapting itself to these conditions, seems to do better on some kinds of soil than on others. It should be the farmer's duty to help the plants as much as he can by planting each on the field best adapted to its needs. Therefore, to plan a rotation properly, it is necessary to know the kind of soil each plant likes best and the kind of soil found in each field on the farm. To study this phase of plant life, the following experiment has been devised:

Apparatus. Soil auger, or spade; a number of small vessels with tight-fitting lids, and a box of crayons or water colors.

Procedure. Bring samples of both the surface and subsoil from each field on the farm at home. Place each sample in a small vessel with a tight fitting lid. Classify each sample, and compare the value of the different subsoils.

Make a drawing of the farm from which the samples were taken. Show each field, the kind of crop grown, the kind of surface soil, and the kind of subsoil. On this farm plan a four years' rotation. Write the name of the crop to be planted in each field and the time of the year it should be planted.

After planning your rotation note how many times each field is to be plowed in the four years. Note how many months each field will lie idle during this time. Upon which fields would you place the barnyard manure in your rotation? Why?

By using colored crayons, and letting different colors denote different soils or crops, a very interesting map may be made.

EXPERIMENT 11.

THE VALUE OF ORGANIC PLANT FOODS.

Object. All matter belongs to either the mineral, animal, or vegetable kingdom. All substances belonging to the animal and vegetable kingdoms are said to be organic. This includes manures, decaying plants, etc. It is the value of these things which we wish to test in connection with plant growth.

Apparatus. Clean sand, two flower pots, some organic matter, such as humus, and a few seeds of some common plant.

FIG. 6
Value of Organic Plant Foods.

Procedure. Clean sand contains all of the mineral plant foods, but does not contain organic matter. We will test the value of organic matter to plants by growing them in sand which does not contain organic matter and in sand which does contain organic matter.

Fill one flower pot with clean sand. Fill the other one about one-half full of the same sand. Then fill it the remainder of the way with organic matter. Mix the sand and organic matter in this pot thoroughly.

The organic matter which you add should be well rotted manure or decayed leaves from the woods. Use whichever is the more convenient.

Plant five or six seeds in each pot and subject both to the same conditions of light, heat and moisture. Observe the results at the end of each week for four weeks or more. Write on the opposite page the results which this experiment shows, making drawings to show the results of your experiment.

EXPERIMENT 12.

WATER HOLDING POWER OF SOILS.

Object. All soils vary in their power to hold water, and it is to show this variation that the following experiment has been devised.

Be sure that the soils used are all about in the same mechanical condition; that is, do not have one kind fine and well pulverized, and another coarse and lumpy. If all of the soils have been screened, they will be satisfactory.

Apparatus. Percolation rack, as shown in cut; four quart bottles, with bottoms removed, or lamp chimneys; cheese-cloth, string, and four small vessels to place under the percolation bottles.

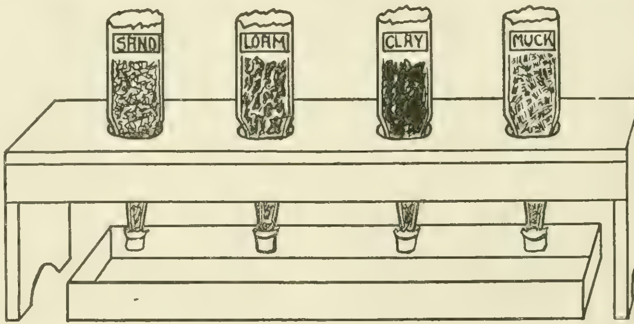

FIG. 7
Percolation Rack in Use.

Procedure. Tie cheese-cloth over the mouths of the percolation bottles or lamp chimneys, and fill each two-thirds full of soil, as follows: Into one put clay; into another, sand; into another, loam, and into the last, humus. Jar each bottle lightly to settle the soil. Place the bottles in the percolation rack and into each bottle pour a pint of water. Observe the amount of water which passes from each bottle. Which soil retains the most water? Which one the least? Can you explain the results of the experiment and its value?

Write three questions about the experiment and discuss its practical value.

EXPERIMENT 13.

PERCOLATION OF WATER.

Object. Water which passes downward as free water is said to percolate through a soil. The rapidity with which percolation takes place is a very important thing for us to know. Upon it depends the distance apart that drains should be placed, the value of fertilizers, the kind of crop, and, in short, the value of the soil itself. This experiment will show, relatively, the rapidity with which water is able to escape through the different kinds of soils.

Apparatus. Percolation rack, four percolation bottles or lamp chimneys, four small vessels to place under the bottles, soils, cheese-cloth and string.

Procedure. Cover the mouths of the percolation bottles or lamp chimneys with cheese-cloth, and fill each bottle two-thirds full of soil. Use a different soil for each bottle. Jar the soil in each bottle vigorously to settle it. Place the bottles in the percolation rack, mouth downward. On each soil pour water until it begins to drip from the mouth of the bottle.

After water is dripping from all of the bottles, note the amount of water which drips through in a given time, say, five periods of five minutes each. Record your results on the opposite page. Be sure that there is a supply of water above the soil in each bottle all of the time.

Which soil loses the most water? Which one the least? Write three questions about the experiment and write the answers. Show them to your teacher. Make a drawing of your apparatus.

EXPERIMENT 13

Name.. Date..

PERCOLATION OF WATER

Number of Bottle	Kind of Soil	Amount of Water Added	Water Percolating in Five Minutes				
			First Five Minutes	Second Five Minutes	Third Five Minutes	Fourth Five Minutes	Average
1							
2							
3							
4							
5							
6							

REMARKS:

EXPERIMENT 14.

PHYSICAL EXAMINATION OF SOIL GRAINS.

Object. When any soil is examined it will be found to consist of lumps of various sizes. These lumps are mostly composed of fine soil particles stuck together. The soil particles vary in size from dust so fine that it will float in water to lumps of solid rock so large that they cannot be moved. Mixed with this mass of rock particles is a great deal of organic matter, in various stages of decay. This amount varies from very little in sandy and clayey soils to the largest portion of muck or gumbo land. Rock particles in the soil vary in color, but it is the organic matter which gives to soil its black color. All fertile soils contain this organic matter, together with clay and silt. Clay consists of the very finest rock particles, which, when mixed with water, will remain in the water for hours without settling. The particles a little larger than the clay which settle in the water slowly are classed as loam. The particles larger than the loam which settle in a vessel of water at once after being stirred are sand. In the following experiment study the size, shape, color, etc., of the soil grains:

Apparatus. Several large glass vessels and samples of air-dry soils to be examined.

Procedure. Place a few grains of each sample of soil on a white paper and examine them with reference to color. Decide the color of the largest part of the soil grains in each sample. Note the shape of the grains, as to whether they are sharp and rough, or round and angular. Are the soil particles single or are they composed of several soil grains stuck together? Are the single particles fine, medium, or coarse? Is the soil gritty or smooth to the sense of touch when rubbed between the thumb and finger? Wet some of each soil and note its stickiness. What causes the difference between different soils? Put a small amount of each sample of soil in a separate vessel and stir it up with water. Pour off the muddy water from each into a separate vessel. Stir the soil three more times with water and pour off the water each time into the same vessel as before. Compare the water which you have poured off of each sample of soil. Which water is the muddiest? Which one the cleanest? Which sample of soil contained the most clay? Which the least? Which one contained the most organic matter?

EXPERIMENT 14

Name.. Date..

PHYSICAL EXAMINATION OF SOIL GRAINS

Soil Type	COLOR				SHAPE		CONDITION		SIZE		
	Percentage of Particles				Percentage of Particles		Percentage of Particles		Percentage of Particles		
	White	Grey	Brown	Black	Angular	Round	Single	Compound	Coarse	Medium	Fine
Clay											
Sand											
Gravel											
Loam											

REMARKS:

EXPERIMENT 15.

TO SHOW THAT MANURES IMPROVE THE TENACITY OF SOILS.

Object. We know that manures are good for a soil, but just why they are valuable is a rather large question. First, manures add plant food to a soil, and, second, they improve the structure of a soil. By structure of a soil we refer to that condition of the soil grains which makes them hard or easy to break apart. A clay soil or any soil that consists of fine soil particles has a tendency to become very hard when dry and sticky when wet. It is this condition which we refer to as the tenacity of soils. We sometimes say of such a soil that it puddles, or bakes, and that it is a heavy soil. These conditions are especially true of a soil that has been cropped regularly for a number of years. Cropping a soil has a tendency to make that soil lacking in organic matter. The addition of organic matter, as manure, to such a soil makes it pack and puddle less easily, thus improving its structure. To show this very important use of manures, perform the following experiment:

Apparatus. Two small pans, some clay, and some very fine organic matter, as leaf mould, or well rotted manure.

Procedure. Put some finely screened clay in each of the two pans. Pour equal amounts of water over the clay in both pans and stir each until you have a thick, well mixed mass. Into one pan pour a little organic matter (a tablespoonful or so) and stir until it is thoroughly mixed with the clay. Set both pans aside for the soil to dry. Which dries first? Why? When thoroughly dry, break or crush the soil in each pan. Note the hardness of each soil. Write two sentences on the value of organic matter to a soil.

EXPERIMENT 16.

CAPILLARITY.

Object. Capillary water refers to that water which passes through a soil due to the attraction which the soil grains have for the water. The oil which passes through a lamp wick is a very good example of capillarity. The oil passes upward because the wick attracts and holds it. Water passes up through a soil in the same manner and this moisture is the most important source of supply for plants. The rate that capillarity will act determines the power of the soil to obtain water from the subsoil, and this in large measure determines the value of the soil. To show capillarity proceed as directed below:

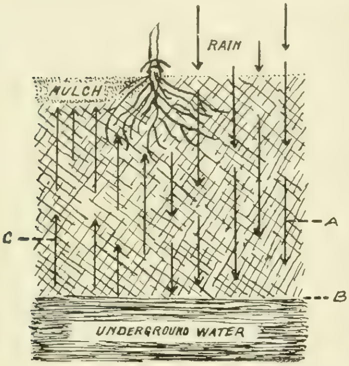

FIG. 8
A Shows Percolation.
B Shows Free Water.
C Shows Capillarity.

Apparatus. Four percolation bottles, a pan about two inches deep and twelve inches long (if this is not to be had, small pans may be used), percolation rack, four kinds of soil, cheese-cloth and string.

Procedure. Take four percolation bottles and cover the mouth of each with cheese-cloth or plug them with cotton. Fill each with a different kind of soil. Clay, sand, loam, and humus are good ones to use. Place the bottles in the percolation rack and arrange the pan underneath them so that the bottom of the pan almost touches the mouths of the bottles. Pour water into the pan until it stands about one-half inch above the mouth of each bottle. Measure the height to which the water rises in the bottles at intervals of ten minutes each. In which soil does the water rise the most rapidly? Which soil do you think would draw the most water from the subsoil? Which one would dry out the quickest? Which soil do you think holds the most water? Write all results in the form on the opposite page.

You might show capillarity by putting one end of an old rag or lamp wick in a tumbler of water and letting the other end hang over the edge. In a short time the end of the rag or wick that is outside of the tumbler will become moist, showing that capillarity has lifted the water over the edge of the tumbler.

EXPERIMENT 16

Name.. Date..

CAPILLARITY

hr. min. Kind of soil..

Time												
Height												

hr. min. Kind of soil..

Time												
Height												

hr. min. Kind of soil..

Time												
Height												

hr. min. Kind of soil..

Time												
Height												

EXPERIMENT 17.

THE THREE KINDS OF MOISTURE IN THE SOIL.

Object. All water that falls upon the soil is divided into three divisions, free water, capillary water, and hygroscopic water. Free water is the water which runs off of the soil, either at the surface of the ground or through an underground drain, as a tile ditch, etc. Very little of this moisture is used by the plant and the farmer should see that it runs off readily.

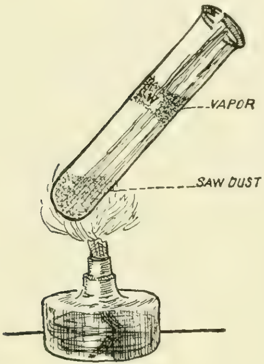

FIG. 9
Hygroscopic Water.

Capillary water, as has been mentioned, is the water which moves about through the soil, due to the attraction of the soil grains. We usually think of it as moving upwards and replacing the water supply in the soil as fast as it is removed at the surface. This source of moisture is of especial interest, since it furnishes most of the moisture for plants. Hygroscopic water is that water which cannot be removed from a soil by natural agencies. This water cannot be used by plants and therefore is of very little value to the farmer.

Apparatus. A percolation bottle, a pint of loam soil, a small pan, a pair of balances, some cheese-cloth and string.

Procedure. Tie a piece of cheese-cloth over the mouth of the percolation bottle. Fill it with the loam soil and jar slightly to settle it. Add water slowly until it begins to drip from the mouth of the bottle. This water is free water. After the water stops dripping remove the soil from the bottle. Weigh it. Spread it out and let it dry until there seems to be no more moisture present. Weigh again. The loss in weight is capillary water. Place the dry soil in a dish and put it in a very hot place, for two or three hours. (The heat should not be above the boiling point of water.) Weigh again. The loss of weight represents hygroscopic water. What kind of moisture is valuable to crops? Can the farmer control any of these forms of soil water? How?

EXPERIMENT 17

Name..

Date..

THE THREE KINDS OF MOISTURE IN THE SOIL

Sample of Soil	Total Weight of Soil	Weight of Capillary Water	Weight of Hygroscopic Water	Total Amount of Water
Clay				
Loam				
Humus				
Sand				

REMARKS:

EXPERIMENT 18.

TO SHOW THAT A PLANT REQUIRES WATER.

Object. It is quite astonishing, to know how much water must pass through the average plant to furnish it food. In an average corn plant from three hundred to five hundred pounds of water are required to pass through the plant to produce one pound of air-dry plant. Thus a corn plant that weighs five pounds when mature has passed through its body a ton of water. Also, a very large part of the average plant is water. In many cases this amounts to over seventy per cent. A ripe tomato contains as much as ninety-two per cent. of water. Milk contains only eighty-seven per cent. Althougn there is more solids in milk than there is in a tomato, we drink the milk and eat the tomato.

FIG. 10
To Show That Plants Require Water.

To show something of the fact that plants do consume water, perform the following experiment:

Apparatus. Four glass tumblers, two healthy plants, some paste or paper stickers.

Procedure. Carefully dig two healthy plants, as clover and wheat, being sure not to injure their roots. Wash the roots clean and place one of the plants in each of two of the tumblers. Now pour water into the four tumblers until it stands at the same height in each and covers the roots of the plants. Paste a piece of paper on each tumbler to show the height of the water in that tumbler. Set all four tumblers aside for a few days. At the end of two or three days, or as soon as the plants begin to wilt, examine the tumblers of water and note the amounts gone. What has become of the water that has left the tumblers that contained no plant? How much more water is gone from the tumblers which contained plants than from those which did not contain plants? How do you account for the difference? Which of the two plants has absorbed the more water? How does the amount of water absorbed compare with the number of roots on each plant?

EXPERIMENT 19.

TO DETERMINE THE EFFECT OF LIME ON A SOIL.

Object. Lime is especially valuable on a clay soil, because it sticks the very fine soil grains together and makes them into larger particles, too heavy to float in water. These larger particles permit air, water and plant roots to pass through the soil more easily than before the lime was added. The process by which the lime sticks the fine soil grains together is called *flocculation.* This process is a great aid to soils, for it not only makes them more open and productive, but it makes them much easier to till. Many fields that are producing very small crops and which are very hard to till need lime to make them again productive. The following experiment shows you very plainly that lime does flocculate or stick together the soil grains:

FIG. 11
(1) Muddy Water with Lime Added.
(2) Muddy Water Without Lime Added.

Apparatus. Two tall glass vessels, some very fine clay soil, a little lime, some distilled water or pure rain water, and a vessel holding a pint or more.

Procedure. Stir a teaspoonful of very fine clay in a pint of water. Let stand a moment and then fill the two glass vessels with the muddy water. Any glass vessels will do. Glass tumblers or beakers are very good for this purpose. Into one of the glass vessels of muddy water put a teaspoonful of lime, and stir thoroughly until it is all dissolved. Leave the second vessel untreated except to stir it thoroughly. Let both vessels stand and observe them every few minutes to note any changes that may occur. In which vessel does the water clear first? Why? What soils need lime? Describe the soil that settled in the bottom of the vessel which contained the clay. How does it differ from the sediment in the other bottle?

EXPERIMENT 20.

THE TEMPERATURE OF DRAINED AND UNDRAINED SOILS.

Object. There is a great difference in the temperature of soils during most of the entire year. This difference is due to several conditions, but one of the most important reasons for it is the drainage which a soil has. In a soil that has no drainage the water which soaks into it will continually pass to the surface and evaporate, keeping the soil cold for a long time. On the other hand, if the soil is drained the extra moisture will be carried away by the drain instead of evaporating at the surface. It is this evaporation which keeps a soil cold. To show that moisture absorbs heat when it evaporates, wet your finger and wave it through the air. The moisture will make your finger feel cool until it has all evaporated.

Also, if a soil is drained the warm spring rains will soak into a soil and force out the cold water, that is present in the early spring. This enables the soil to become warm very rapidly. If there is no drainage the warm spring rains run off at the surface and the soil remains cold until very late in the spring. We say of such a soil that it is a late soil. Try to bring out these facts in the experiment.

Apparatus. Two tin cans, some soil, a hammer and nail, and two thermometers.

Procedure. With the nail punch a number of holes in the bottom of one of the cans. This is to provide drainage for the soil in that can. Leave the other can water-tight. Fill both cans with the same kind of soil and saturate each with water. Insert a thermometer in each can of soil and take readings, every two or three hours, for a day or two. Compare the readings of the two soils. What can you say of the effect of drainage upon the temperature of soils? About how deep should a tile drain be placed? How far apart should they be laid? What is meant by a four-inch tile?

EXPERIMENT 20

Name.. Date..............................

THE TEMPERATURE OF DRAINED AND UNDRAINED SOILS

DRAINED SOIL

	hr.	min.										
Time												
Temperature												

UNDRAINED SOIL

	hr.	min.										
Time												
Temperature												
Difference												

REMARKS:

EXPERIMENT 21.

THE WEIGHT OF DIFFERENT TYPES OF SOIL PER CUBIC FOOT.

Object. If soil contained no open spaces between the soil grains, but consisted of solid rock particles, it would weigh about 165 pounds per cubic foot. But a cubic foot of soil never weighs this much, because it does not consist entirely of rock particles, and besides it contains quite a lot of pore spaces. Organic matter is lighter than rock particles, consequently, as a rule, the more organic matter there is in a soil the lighter it is. Therefore, by weighing different air dry soils we can in a general way compare their pore space and the amount of organic matter to be found in each.

Apparatus. Some vessel that is rather large (holding a quart or more) with a smooth top and having the same diameter from the bottom to the top; soils to be examined; ruler, and a pair of scales.

Procedure. Measure the vessel which you have for this experiment and figure its volume. Weigh it empty and record the weight. Fill it with one of the soils to be tested, and jar to settle the soil. When completely settled and full, level the top with a straightedge, such as a ruler. Weigh it and record the weight. Subtract from this weight the weight of the vessel when empty and the difference will give you the weight of the soil alone. From this weight figure the weight of the soil per cubic foot. Empty the vessel and proceed with the next sample as above. Write down all results and compare the weight of the soils with the texture, color, etc. Figure the weight of a cubic foot of organic matter. How does its weight compare with the weight of the soils?

EXPERIMENT 22.

THE AMOUNT OF AIR IN SOILS.

Object. On an acre of ground to a depth of one foot there is an enormous amount of air space. This air space is necessary, for plant roots require air. Also the bacteria in the soil which are so necessary to plant life must have air to breathe. Without air in the soil decay could not take place and no organic matter would become valuable as plant food. As a general rule, the more air there is in a soil the more rapidly decay takes place. In soils that are very porous the decay of organic matter takes place too rapidly and organic fertilizers are soon lost. On the other hand in very compact soils, as clay, decay usually takes place so slowly that plant food does not become available rapidly enough to supply the needs of growing plants. In the following experiment we will endeavor to find out how much air space there is in various types of soils.

Apparatus. Three or four tin cans with sharp edges where the lids have been removed; a ruler, and a measuring glass.

Procedure. Measure each tin can and figure its volume. Then force each into the ground which you desire to test, until it is quite full of soil. Do not fill the cans by digging the soil and putting it into them, for this destroys the natural pore spaces. Dig up each can and set aside until the soil becomes thoroughly dry. Carefully pour water on each sample of soil, keeping account of the water used. When the soil is completely saturated with water note the total amount of water used. From this figure the percentage of the soil sample that was air space. Compare the amount of air space in each soil.

EXPERIMENT 22 (b).

THE EFFECT OF LIME ON SOIL STRUCTURE.

Object. To show that the structure of a soil may be modified by an indirect fertilizer perform the following experiment:

Apparatus. Three shallow pans; some very fine screened clay soil, and a little powdered lime.

Procedure. Stir some clay soil with water until it becomes a sticky mass. Fill one of the shallow pans with this sticky soil. Stir into the remainder of the sticky clay soil a few teaspoonfuls of powdered lime. With this fill the other shallow pan. Smooth the soil in the two pans and set them aside to dry. Which pan of soil dries first? Why? Which one crumbles the easiest in the hands? What can you say of the effect of lime on a clay soil?

EXPERIMENT 23.

WHAT A SOIL MULCH DOES.

Object. We have learned that water passes upward through the soil by means of capillary action and evaporates at the surface unless something prevents it. We want the moisture to come from the soil below to the surface soil to supply moisture for growing plants; but we do not want it to evaporate into the atmosphere, for if it does the water is lost and the soil becomes colder. If we stir the surface soil to a depth of three or four inches the capillary action is broken and the water can climb only to this place where the soil is stirred. Thus by stirring the surface soil we permit the moisture to come almost to the surface and there it stops and remains until the plant can use it, for it does not reach the air to evaporate. This stirring produces a fine layer of soil over the surface. This fine layer of soil is called a mulch. You can perform the following very interesting experiment to show just how a mulch checks soil moisture.

Apparatus. Three loaves of cube sugar; a little powdered sugar; a small shallow pan; and a colored solution, such as red dye or water colored with red ink.

Procedure. Sprinkle on top of each loaf of cube sugar a thin layer of powdered sugar. This thin layer is to represent a soil mulch. Carefully stack the loaves of cube sugar upon one another with the layers of powdered sugar between. Set the whole thing in a shallow pan. Pour into the pan the colored solution. Watch the rise of the colored solution through the cubes which represent the soil and through the powdered sugar which represents the mulch. Note the time required for the solution to pass through the cubes as compared with the time required for it to pass through the layers of powdered sugar. How does the time required compare with the thickness in each case? Write a discussion on the value of mulches to save moisture.

EXPERIMENT 23

Name.. Date..

WHAT A SOIL MULCH DOES

	First Cube	Second Cube	Third Cube	Fourth Cube
Time				
	First Mulch	Second Mulch	Third Mulch	Fourth Mulch
Time				
Difference				

REMARKS:

EXPERIMENT 24.

TO SHOW THE EFFECT OF WEATHERING UPON SOILS.

Object. There are many agencies at work all of the time forming soils out of large rock particles. Freezing and thawing is one means of forming soil and is about as important as any other agency at work. When water freezes in the soil it expands and forces the soil grains apart. Even large rocks are slivered by the action of freezing water. The accompanying picture shows what freezing has done to a mass of large rocks.

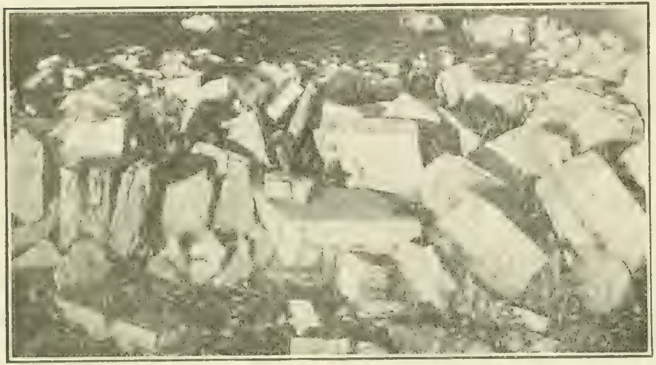

FIG. 12 How Weathering Breaks Up Limestone.

Apparatus. Pan; stirring rod, and some clay soil.

Procedure. Stir some clay with water and make it into a very thick, pasty mass that can be worked in the hands. Make the sticky clay into three balls of about the same size. Put one where it will freeze; leave another where it will remain at an ordinary temperature and place the third in a very hot place where it will bake. At the end of two days compare the three balls of clay. Describe each as to its hardness. What is the action of heat upon clay? Which ball of clay dried first? Do you think that the rapid loss of moisture from this ball had anything to do with its hardness?

EXPERIMENT 24 (b).

Fill a glass bottle with water and cork it tightly. Set it where it will freeze. What happens to the bottle? What happens to iron water pipes when they freeze? Go to a field where there is a large rock and examine it. Do you find any slivers of rock that have been broken off of its surface? How were they broken off? Do you think that there is any advantage in plowing a field in the fall?

EXPERIMENT 25.

THE EFFECT OF PUDDLING A SOIL UPON THE PASSAGE OF MOISTURE.

Object. Puddling soil not only makes it hard and useless as a plant food, but it prevents water, air and plant roots from passing through it. When we plow a soil that is too wet to plow, the soil grains get very close together and the soil is said to puddle. This is especially true in the bottom of a furrow. The plow sole slicks over the bottom of the furrow and firms the soil into a compact layer. This prevents the moisture below from coming up for the use of plants and prevents the roots of plants from reaching the subsoil to obtain moisture. Such a condition makes a soil almost worthless for growing crops except in the case of a very sandy soil. A sandy soil will not puddle and the firmer we can get it the better. Can you see why a sandy soil should be as firm as possible? This experiment will show you what effect puddling a soil at the bottom of the furrow has on the passage of moisture, either upward or downward, through the soil.

Apparatus. Four percolation bottles; a percolation rack; some clay soil; a stirring rod; a pan; cheese-cloth and string.

Procedure. Tie cheese-cloth over the mouths of the percolation bottles. Fill two of them one-third full of finely screened clay soil, and fill the other two almost full of the same soil. These two are for controls. Stir a little clay and water together in a pan until they are thoroughly mixed into a thin batter. Pour about an inch of this batter into each of the two bottles which you have already filled one-third full. Finish filling the bottles about two-thirds full with the fine clay. Now put the four bottles in the percolation rack and leave until the puddled layers of soil are dry. This will take a day or more. Then put the mouth of one bottle which contains the layer of puddled soil and one of the control bottles in a pan of water. Pour water in at the top of the other two bottles. How does the puddled layer of soil affect the passage of water upwards? What is the passage of water upward through a soil called? What is the effect of the puddled layer of soil on the passage of water downward? Does a farmer gain by plowing his soil wet?

EXPERIMENT 26.

THE EFFECT OF DIFFERENT KINDS OF MULCHES.

Object. When we stop to think that a plant requires most of its moisture during the hot summer months, when very little rain is falling, we can see that the saving of soil mosture, by means of mulches, is a very important thing. Some mulches are more effective than others and it is to show this that the following experiment has been devised:

Apparatus. Six empty tomato cans; a pair of balances; loam; sand; clay; well decayed manure, and straw or chaff.

Procedure. Fill all of the cans with fine loam soil, after having punched a number of holes in the bottom of each with a nail. Pour water into each can until the soil is filled with water. Set the cans aside until the soil is dry enough to cultivate. This should take a day or more. Then remove an inch of soil from all but one of the cans. Replace this inch of soil in each as follows: In one can put dry sand; in the second use fine clay; in the third use fine loam; in the fourth use well decayed manure, and in the fifth use finely chopped straw or chaff. Leave the sixth untreated for a control. Now weigh each can and write its weight on the opposite page. Weigh each can every day for three days. Record the weights on the opposite page. Compare the amounts of moisture lost from each can. Which mulch is the most effective? Which one the least? Do you think that a straw mulch over a potato patch would be of any practical value?

EXPERIMENT 27.

TO SHOW THE AMOUNT OF ORGANIC AND MINERAL MATTER IN SOILS.

Object. The amount of organic matter in a soil is a good indication of its fertility. A soil that has a good supply of organic matter usually has a large supply of nitrogen, which is one of the most valuable plant foods. All organic matter has its source in the air, and if you heat a substance containing organic matter it will go back into the air. All matter that will not burn is known as mineral matter.

Apparatus. A large iron spoon; a little loam or muck soil, and a flame.

Procedure. Weigh out a few ounces of finely screened soil and place it in a large iron spoon. Heat this soil in a flame until everything that will burn has been removed. Weigh that which is left. It is mineral matter, while that which has been removed is organic matter. Can you figure what part of this soil is organic matter? Do you think that your sample of soil was a rich or a poor soil? Why? Perform this experiment with several samples of soil and compare the results from each sample.

EXPERIMENT 28.

POTASH AS A PLANT FOOD.

Object. Not more than a dozen elements enter largely into the composition of the earth's crust, and only ten of these are absolutely necessary to plant life. Of the ten plant foods which every plant must have we need concern ourselves with only three, for the remainder are present in such large amounts that we need give them no attention. The three which need our attention and which are often lacking in a soil are nitrogen, phosphorus and potash. Potash usually goes to make up the stem and leaves of a plant. It is usually present in sufficient quantities for the needs of a plant, but sometimes it must be added to a soil to make that soil productive. The lack of potash can sometimes be detected by the appearance of the crop. A blue green color in plants instead of the healthy green color which they should show denotes a lack of potash. Also when plants blow over badly, due to the fact that their stems are not stiff enough to support them, it is usually a sign of not enough potash. We often hear a farmer say that his oats have lodged badly. Sometimes this is due to other causes, but it has usually fallen over on account of a lack of potash in that soil. Some special crops, as tobacco, require very large amounts of potash, and a soil on which such crops are grown regularly should have potash added.

Apparatus. Some fresh wood ashes; a pan; litmus paper; hydrochloric acid or vinegar, and a flame.

Procedure. Soak some wood ashes in water for a day or more. Drain off this water and evaporate it. Collect the dry material that is left after the water evaporates. Note the soapy feel which it has when rubbed between the fingers. Test it with litmus paper. Is it an acid or a base? (An acid turns litmus red and a base turns it blue.) Mix a little acid with it. What happens? Carefully taste a little of the dry powder. How does it taste?

EXPERIMENT 29.

TO LEARN THE EFFECT OF PLOWING UNDER MANURES.

Object. Green manures and barnyard manures are often plowed under late in the spring. If they do not have time to decay before the crop is planted they cause serious loss of moisture by cutting off the water supply from below. Notice carefully the following experiment for it brings out several points of value and interest:

Apparatus. Three percolation bottles; a percolation rack; some straw or hay chopped fine; some well-rotted manure; a pan; some clay or loam soil; cheese cloth, and string.

Procedure. Cover the mouths of the percolation bottles with cheese cloth and place them in the rack with the pan underneath. Now fill each bottle one-half full of fine clay or loam soil. Then put about an inch of finely cut straw in one bottle, about the same amount of well-rotted manure in another bottle, and leave the third untreated. (This is for a control.) Put an inch or more of soil in the first two bottles over the straw and manure, and about two inches of soil in the third bottle. Use for this the same kind of soil that you used in the bottom of the bottles. Pour water into the pan under the bottles until it stands about an inch above the mouth of each bottle. Note the rapidity with which the water rises in the bottles. Compare the time required for the water to pass through the soil with the time required for it to pass through the straw and manure mulches. In which of the three bottles does the moisture reach the top first? How do you account for this? In your experiment the straw and manure represent the material plowed under and the soil above this the surface soil in which the plants must grow. If straw or coarse manure is to be plowed under, do you think that it should be done in the spring or in the fall? Why? How would such a mulch as that made by the straw or manure do if it were placed on top of the soil after the crop was planted? What is a mulch? Write a discussion upon mulches to save soil moisture.

EXPERIMENT 30.

JUDGING A PLOW.

Object. The primary and most important tillage machine is the plow. It is more important than most people realize. We usually feel that there is not much difference between plows, but that a plow is a plow, no more and no less. Although a plow is not very complex, it is very delicately adjusted, and if improperly made or set it will do very poor work. A walking plow has three very important points for us to consider. These three points are the share, the landside and the mouldboard.

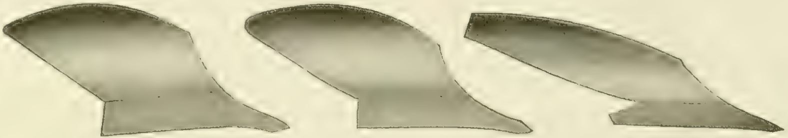

FIG. 13
The Three Common Types of Mouldboards.

Apparatus. A walking plow, a dull plowshare, and as many other types of plows as you can find.

Procedure. In judging a plow give attention to the following details: Name of the plow; where made; whether the plow is best suited for sod or for stubble; size of the plow; vertical distance from point of share to the highest point of the beam; the concave nature of the landside; the concavity of the bottom of the plow along the landside. Explain the value of this concave construction. Explain the especial use of each of the mouldboards shown above. Explain why the mouldboard has a high polish. Examine a dull plowshare and point and compare it with a sharp one. What is the value of having a plowshare and point sharpened often? In a like manner, examine a riding or sulky plow. Compare the two and make note of any differences that you may find. If there is a hardware store in your town, have the dealer explain to you the different kinds of plows and their construction.

EXPERIMENT 31.

TESTING SOILS FOR ACID BY MEANS OF LITMUS PAPER.

Object. Litmus is a substance extracted from certain plants which has the peculiar property of turning red in the presence of an acid (as vinegar) and blue in the presence of a base (as soda). Litmus paper is made by dipping paper in a solution of litmus. It may be purchased at almost any drug store and is very cheap. Special litmus paper that is extra sensitive to the presence of acids can be purchased at chemical supply houses, but this is unnecessary if the ordinary paper can be had. You might test many substances with litmus paper and determine whether they are acids or bases. The same piece of litmus paper can be used many times.

Apparatus. Two glass vessels, as tumblers or beakers; some blotting paper; litmus paper, and some soil to be tested.

Procedure. Cut a piece of blotting paper to fit inside of one of the vessels. Under this blotting paper in the bottom of the vessel, place a piece of litmus paper. On top of the blotting paper place an inch or more of the soil to be tested. Add enough water to saturate the soil. Prepare a second tumbler like the first except leave out the soil. Use the same amount of water in this vessel that you used in the first one. This is for a control. (To show that your work is correctly done.) Set both vessels aside for a few minutes. Then examine the litmus paper through the bottom of the vessels. Note any changes of color that may have taken place. A red or pinkish color denotes the presence of a large amount of acid; a neutral color (neither red nor pink) denotes a slightly acid condition; while a blue color denotes an alkaline or basic condition. To determine the color of the litmus paper in the vessel which contains the soil compare it with the litmus paper in the vessel which you have for a control. The paper in this vessel should not have changed color. Repeat the experiment, using a soil to which you have added lime. Also test samples of soils to which you have added fertilizers of various kinds. How would you correct an acid soil? What are the disadvantages of an acid soil?

EXPERIMENT 32.

TESTING SOIL FOR ACID BY MEANS OF AMMONIA.

Object. Limestone is one of the most important things that we find in the soil. While lime is not a plant food, no soil could long be productive without it. When a soil is lacking in lime we say that it is sour. This means that it contains acid. When lime is present we say that it sweetens the soil. There are several methods of telling whether or not a soil is acid, and no land owner should neglect to determine this important fact regarding his soil. For this test bring some soil from home which you have collected in the following manner: Go to a field that you desire to test and scrape away the surface plants and soil to a depth of about an inch. At this depth collect about a half pint of soil. Now dig down at this same place to a depth of twelve inches and take another sample like the first one. Two samples of soil are taken because the surface soil sometimes shows acid while the subsoil is sweet. The following test is more reliable than the litmus test and will tell you whether or not your soil is acid.

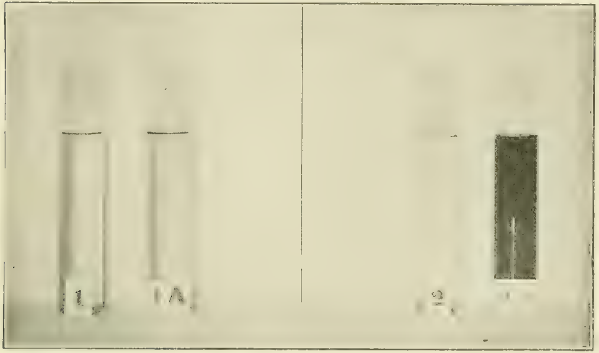

FIG. 14

(1) Water and Soil. (1A) Water, Soil and Ammonia, Showing a Sweet Soil.

(2) Water and Soil. (2A) Water, Soil and Ammonia, Showing Acid Soil.

Apparatus. Two tall glass vessels (see picture); soil to be tested, and ammonia.

Procedure. Place in each glass a teaspoonful of one of the samples of soil to be tested. Then fill both glasses with water, and to one glass add a teaspoonful of ammonia. Stir both glasses thoroughly, and if at the end of an hour the water which contains the ammonia is colored quite dark and the other settles clear the soil is acid. Repeat the experiment with the other sample of soil and write the results of the tests on the opposite page.

EXPERIMENT 33.

TESTING SOILS FOR NITROGEN.

Object. We usually think of a black soil as a rich soil. When anyone says that his farm is composed of black soil we at once regard it as a rich soil. The black color of the soil usually denotes that the plants which grow in it will be large, green and healthy. This is due in part to the nitrogen which is present. It is very valuable to be able to tell how much nitrogen there is in a soil, for while a black soil is usually rich in this element, the color of a soil is not always a safe guide to its nitrogen content. To tell accurately the amount of nitrogen in a soil requires elaborate equipment, but there has been devised a method which will answer for all practical purposes and which does not require much apparatus.

Apparatus. A ten per cent solution of caustic potash, which can be obtained at almost any drug store; soil to be tested, and two tall glass vessels which can be heated. Ordinary lye may be used to supply the caustic potash, although it is an impure form of this substance.

Procedure. In a clean vessel to two tablespoonfuls of the soil to be tested add fifteen tablespoonfuls of ten per cent caustic potash solution. In another vessel add to two tablespoonfuls of soil fifteen tablespoonfuls of water. This is for a control. Heat both samples to the boiling point. Set them aside for five minutes. If at the end of that time the solution which contains the caustic potash is black and opaque the soil is rich in nitrogen. If, however, it is merely dark and allows light to pass through it, the nitrogen content of the soil is low. If the solution is merely yellow there is practically no nitrogen content. Compare the sample which contains the caustic potash solution with the one which contains the water. What difference do you observe in the two samples? Perform the same experiment with several samples of soil and write the results on the opposite page.

EXPERIMENT 34.

TO SHOW THAT SOILS ABSORB FERTILIZERS.

Object. We know that soils differ in the amount of plant food which they contain, and also that fertilizers placed upon different soils produce very different results. One reason for this is because different soils absorb plant foods in different amounts.

When manure or commercial fertilizer is placed on a soil, the first rains that fall dissolve much of the plant food in the fertilizer. This food would be carried away if the soil did not absorb it from the water. All soils try to absorb this plant food, but some soils can hold it much better than others. Fine soils as clay have a great deal more power to absorb plant foods than coarse soils like sand. For example, if we were to put manure on a sandy soil the rain would carry away most of the plant food. But if we put it on a fine clay soil, the rain could not carry so much of the food away, for the soil would hold it. In this experiment you will expect different soils to hold different amounts of plant food, and the finest soils to hold the most.

Apparatus. Some red dye or red ink; four percolation bottles; cheese cloth; string; percolation rack; four types of soils, and four small vessels to go under the bottles.

Procedure. To show that soils absorb plant food from water we will have to pour water over soils and have in this water something that we can see which represents the plant food. Color some water by adding some dye or red ink to it. Fill the percolation bottles with equal amounts of different kinds of soil and pour some of the colored water on each soil. Collect the water which drains through each soil. Which soil permits the most color to pass through? Would it be a good plan to apply fertilizers in large amounts at a time to a sandy soil? Why not?

EXPERIMENT 35.

JUDGING A FARM.

Object. We consider it important to judge and score corn, cattle, horses, and indeed all products on the farm, whether they are plants or animals. How much more important it must be to judge and score the farm itself, from which all plant and animal life must come. The outline or score-card on the following page should be modified to suit the local conditions; however, the points below are important and should receive consideration.

Apparatus. Any farm which is convenient to judge.

Procedure. Give particular attention to the following points, filling in the score-card on the opposite page.

(a) Size. (3) The size of a farm determines in a large measure the kind of farming that can be attempted. A farm is ofttimes too small for the kind of farming practiced and almost as often too large. For example, we sometimes find grain farming practiced where dairying would be more profitable, or we find dairying carried on where horticulture is better to be practiced.

(b) Field Arrangement. (6) Fields should be so arranged that there will be as little loss of room as possible, in the form of lanes, odd sized corners, etc. They should be so sized that none of them are excessively small, and they should be so joined that each field could be reached without driving any unnecessary distance.

(c) Surface. (6) The fields should be rather smooth for grain farming. For pasture or timber the ground does not need be so level.

(d) Fertility. (12) Fertility is the very basis of successful farming, and consequently should be looked to carefully. We desire any farm to be in the highest state of natural fertility possible.

(e) Physical Condition of Soils. (12) Physical condition determines whether a soil is an early or a late soil, whether it is easy or difficult to till, and the necessity of using soil amendments.

(f) Drainage. (8) Every foot of a farm should be well drained, either naturally or artificially. Poor drainage means a poor farm.

(g) Farm Improvements. (20) The term, "Farm improvements," refers to fences, buildings, roads, ditches, and a host of details which each particular kind of farming demands.

(h) Healthfulness. (4) Things which might influence healthfulness are disagreeable industries carried on close by, contaminated streams, swamps adjoining or on the farm, and climate, which in some places is unhealthy.

(i) Location. (25) A desirable farm will be on good roads, near a market and close to public institutions.

(j) Water Supply. (4) Springs and running streams are valuable sources of water supply. They should be examined carefully, however. All wells should be examined to be certain that they are not impure.

EXPERIMENT 35

Name.. Date ....

JUDGING A FARM

Point Considered	Perfect Score	Student Score	Corrected Score	Error	Remarks
(a) Size					
(b) Field Arrangement					
(c) Surface					
(d) Fertility					
(e) Physical Condition of Soils					
(f) Drainage					
(g) Farm Improvements					
(h) Healthfulness					
(i) Location					
(j) Water Supply					

EXPERIMENT 36.

THE AMOUNT OF MOISTURE REQUIRED TO GERMINATE SEEDS.

Object. To determine the comparative amount of moisture required to germinate seeds. It is well known that some seeds require more moisture for germination than others. If we can compare the different kinds of seed and see which ones require the most moisture, we will know which ones require the firmest seed beds. Also, we can determine which kind of seeds respond to the best advantage to rolling or firming the seed bed after planting.

Apparatus. A piece of glass three or four inches wide and a foot or more in length (a board may be used if glass is not to be had), two or three large sheets of blotting paper; a wide, shallow pan, and seeds to be germinated. You should have four or five varieties of seed—more if possible.

Procedure. Take the glass or board which you have obtained and see that it is smooth and clean on one side. Then arrange it at a very slight angle with one end resting in the pan. The top end of the glass should be three or four inches higher than the bottom end. Cover the top side of the glass with blotting paper. If you have sufficient paper, use two or three layers. After the blotting paper is in place, carefully lay the different varieties of seed in rows from the bottom to the top of the glass. When this is done pour water into the shallow pan until it covers the end of the blotting paper and the first few seeds in each row. Place the apparatus in a warm place and watch the results. Which seeds germinate first? Which variety of seed germinates the greatest distance up the board? Which one the least? Which variety of seed requires the most moisture? Make a drawing on the opposite page to show as nearly as possible the results of your experiment.

EXPERIMENT 37.

TO TELL THE EXACT AMOUNT OF LIME IN A SOIL

Object. There has been devised many simple experiments to tell whether or not a soil is acid. All of these experiments are more or less inaccurate, and while they are very good for quick determinations, the following method is much to be preferred. This experiment tells, not only, whether or not lime is present in a soil, but how much is present.

Apparatus. A bottle; a two-hole rubber stopper; a piece of glass tubing; some rubber tubing; thistle tube; a measuring glass that measures cubic centimeters; hydrochloric acid; a rather deep pan, and a pair of balances.

Procedure. Weigh out ten grams of the soil to be tested. Put this soil in the bottle and insert the rubber stopper. Through one hole in the rubber stopper put the thistle tube. Through the other hole, by means of the glass and rubber tubing, arrange to conduct the gas that is formed to the bottom of the deep pan. This pan should be half full of water. Fill the measuring glass with water and, holding the hand over the mouth, suddenly invert it and put the mouth under water in the deep pan. This should leave the measuring glass filled with water. Put the end of the glass tube that connects with the bottle under the mouth of the measuring glass. Now pour hydrochloric acid into the bottle through the thistle tube. Be sure that none of the gas which is generated escapes through the thistle tube. Also see that all joints are air-tight. When you pour acid over the soil it will bubble and give off a gas. This gas will pass out through the glass tube and will bubble to the top of the measuring glass. When all action ceases and no more gas passes off note the amount of water that has been displaced by gas. Divide this amount by two hundred and twenty-two and the answer will give you the number of grams of lime in ten grams of soil. From this you can easily figure the percentage of limestone there is in a soil.

If you perform this experiment accurately it should give you very good results. Use care in each step of the experiment, for inaccuracy always leads to wrong conclusions.

Be especially careful that you get exactly ten grams of soil in the bottle. The amount of acid does not matter, so that it moistens all of the soil thoroughly.

EXPERIMENT 38.

BACTERIA.

Object. Of all known plants bacteria are perhaps the smallest, as well as the simplest, for they usually consist of only one cell. They cannot be seen by the naked eye except when they occur in large masses. Usually they do not make their own food, but live on the dead or living bodies of other organisms. Bacteria multiply rapidly by merely dividing in the middle. They sometimes divide as often as every twenty minutes, so that in a very few hours one plant may produce a million. Since they are so numerous and so small they are found almost everywhere. They are present in food, water, dust, and are even found floating in the air.

Most bacteria are harmless, and some are even beneficial; but others are very injurious. This latter kind often produce dangerous diseases in plants and animals. Most contagious diseases of man are caused by bacteria.

The action of bacteria that sours milk is very easily seen, and we will try to see, in the following experiment, how they behave:

Apparatus. A little of the first of a milking; a little of the last of a milking, and two clean vessels.

Procedure. Obtain a little of the first of a milking in a perfectly clean vessel. In another clean vessel obtain a little of the last of the milking. Set both vessels of milk in a warm, clean place and note which sours first. Why is this true? After both dishes of milk have soured, empty them. Wash one dish with hot water. Do not wash the other. Put sweet milk into both dishes. Which one sours first? How much sooner does this one sour than the other? Why?

Milk is almost a perfect food for bacteria and they thrive in it very readily. Indeed, it is very hard to keep milk sweet a very long time for this reason. Bacteria in the soil behave similar to the bacteria in milk. They attack organic matter and decompose it. The bacteria which live on dead organic matter are called saprophytes. Those which live on living matter are called parasites. We will discuss parasites in the next experiment.

If you have a high-power microscope examine specimens of various kinds for bacteria.

EXPERIMENT 39.

BACTERIA OF LEGUMES.

Object. Bacteria which thrive on living material are called parasites. The bacteria which thrive on legumes are of this class. These bacteria not only live on the legumes, but in a peculiar way help the legumes to thrive. At one time, no doubt, they injured the plant, but after years of growth they have become adapted in such a way that they are almost necessary to the growth of any legume. Let us try in an experiment to see if we can show the benefit of bacteria to a clover plant:

FIG. 15
Nodules on Roots of Soy Beans.

Apparatus. Soil, two flower pots of medium size, formalin, clover seed to be planted, and an oven for heating soil.

Procedure. Fill two flower pots of medium size with soil. Rich soil dug from a field where clover is growing should be used for this experiment. Sift the soil through a fine screen to remove all large particles, roots, etc. Heat the soil in one flower pot in an oven for an hour. This will sterilize the soil if the heating has been thorough. If the flower pot is a very large one, heat the soil in it for two hours. Sterilize the seed to be planted in one pot, as follows: Immerse the seeds in a two per cent. solution of formalin for a few minutes. Plant these sterilized seeds in the soil that has been heated. Plant a like quantity of unsterilized seeds in the other pot of soil. Now place both pots under the same condition of heat, light, etc., for some time. The nearer the plants reach maturity the better. At the end of several weeks remove the plants from the flower pots. Do this very carefully, so as not to injure the roots. Examine the roots for bacteria. How do the plants compare as to size? Explain in writing the results of your experiment.

SUPPLEMENTARY EXPERIMENTS

EXPERIMENT 40.

THE VALUE OF COMMERCIAL FERTILIZERS.

One of the best ways to show the value of commercial fertilizers in an indoor experiment is by means of plant food tablets. You can purchase these tablets already prepared or you can make a similar preparation. Your druggist will supply you with the materials weighed out and mixed if you will give him the formula. The plant food tablets consist of the following:

Common Salt	5 grams
Epsom Salts	5 grams
Plaster of Paris	5 grams
Phosphate of Lime	5 grams
Saltpetre	10 grams
Ferric Chloride	¼ gram

When the above mixture is thoroughly mixed weigh out two grams. Mix this two grams of plant food with a gallon of rain water. The rain water should be caught directly in a clean pan. If it touches a roof or anything of that nature it will pick up impurities. Keep this plant food solution in a tightly closed, clean bottle.

Obtain two small flower pots and enough clean sand to fill them. Cover this sand with water in a vessel that can be heated. Heat until the water boils. Pour off this water and heat the sand again with more water. When this water boils pour off the water and heat the sand until it is dry. Fill the two flower pots with this sand and in each pot plant several different varieties of seed. Subject both pots of seed to the same conditions, except water one with pure rain water and the other with the solution which you have prepared.

What difference do you note in the plants at the end of two or three weeks?

Why is it that you find no apparent difference between the two pots of plants at the end of the first week?

Can you tell what plant food each of the substances in the plant food tablet furnishes?

EXPERIMENT 41.

A COLLECTION OF PLANT FOODS.

In your experiments previously performed you have experimented with potash, lime, nitrogen, acid, etc. Now, in order that you may know more fully what these plant foods are like, make a collection of them and place each in a bottle properly labeled.

Obtain some charcoal and label it carbon. Can you name other substances that are principally carbon? Get some quicklime and label it calcium oxide. Obtain some limestone rock and label it calcium carbonate. Obtain and label properly raw rock phosphate, acid phosphate, magnesia, sulphur, iron rust, nitrate of soda, sand, muriate of potash, saltpetre, and any others that you can find.

Place these bottles in a case and keep them for use in the laboratory. They will come handy later on in your work on soils.

EXPERIMENT 42.

THE EFFECT OF DIFFERENT KINDS OF FERTILIZERS ON PLANTS.

From a fertilizer company get samples of all of the different fertilizers that you can obtain. Obtain some average clay, loam, and sandy soil. Fill a flower pot with each type of this soil. Put a little of the same kind of fertilizer in each of the three pots. Plant seeds in each pot and subject all of them to the same conditions of heat, light, moisture, etc. Compare the plants at the end of a week; at the end of four weeks. In a like manner try each fertilizer that you have obtained on each of the three types of soil. Write the results of your experiments in full.

This experiment can be made as extensive as the teacher desires. Pot cultures, showing the value of different fertilizers on different soils and crops, are very accurate if properly performed. The advantage of pot cultures over outdoor cultures is the inexpensiveness of the pot cultures and the fact that they can be performed during the winter months. Also, inside conditions of heat, light, moisture, etc., can be controlled to a much better advantage.

EXPERIMENT 43.

TESTING WATER FOR IMPURITIES.

Of all the impurities usually found in water organic matter is the most undesirable. Water which is known to contain organic matter should not be used for drinking purposes. The following is a very simple test for organic matter:

Fill a clean glass vessel that you can heat with a sample of the water to be tested. Add a drop or two of concentrated sulphuric acid and sufficient potassium permanganate solution to color the water a light red. Heat the solution gently to the boiling point. If the color changes from a red to a brownish tint, it indicates the presence of organic matter.

There are many other impurities to be found in drinking water. The following substances to be tested for are not particularly harmful to drinking water if found only in small amounts. They indicate the presence of plant food if found in soil water.

To Test for Chlorides. To a test tube or glass vessel half full of water to be tested add a few drops of nitric acid and then a few drops of silver nitrate solution. If there is any cloudiness it shows there are traces of chlorides in the water.

To Test for Sulphates. Fill a test tube or glass vessel that can be heated half full of water to be tested. Add to this water a few drops of barium chloride solution. If there is a whitish precipitate it indicates the presence of sulphates in the water.

To Test for Lime Compounds. Fill a test tube or glass vessel that can be heated one-half full of water to be tested. Add to this water a few drops of fresh ammonium oxolate solution. A whitish precipitate denotes the presence of lime compounds.

Test soil water, drinking water, and rain water for each of the above substances and write the results in your note book. The chemicals needed for this experiment can be purchased at a very small cost from almost any drug store.

EXPERIMENT 44.

TO SHOW THE VALUE OF DRAINAGE.

Mix thoroughly four tablespoonfuls of soda with three pints of fine soil. Put one-half of this soil in a can that will hold water. Pour water over this can of soil until it is saturated with water. Set it aside to dry.

In another can that has holes in the bottom put the remainder of the soil. Pour water over it until water runs freely from the bottom of the can. Place this can with the other one to dry. When the soil in both cans is dry examine the surface of each soil. What difference do you note? How do you account for the white particles that have gathered at the surface of the one can? What do you think would become of the poisonous substances in an undrained soil? What would become of them in a drained soil? Is drainage a very valuable aid to crop production? Which land would supply water to a growing crop for the longer period of time, a well drained soil or a similar soil not drained? Why?

EXPERIMENT 45.

LOSSES OF MANURES.

Obtain a box that will hold ten or fifteen pounds of manure and which is tight enough to prevent it from sifting out. Weigh the empty box and record its weight. Fill the box with fresh manure and re-weigh it. Now place the box of manure out of doors and after three or four weeks re-weigh it. How much difference is there between the weight before and after exposing the manure to weathering? What has become of this material? Figure from the above weights the percentage of weight that is lost from the manure. Is this material which is lost valuable? Which is the more valuable, the manure retained or that part which is lost? Why? What can you say of the practice of storing manure out of doors?

EXPERIMENT 46.

MAKING COMPOST.

Compost is made by piling up alternate layers of manure and soil and letting the mass decay. Sometimes when the compost is to be used for special purposes fertilizers are added. Make some compost for use in your experiments in the following manner:

First select a high place, preferably where it is shady, and see that it is well drained. Then make a foundation for your pile of compost out of a layer of sod. On top of this place a layer of manure and vegetable matter about six inches thick. On top of this place another layer of sod. Continue piling up alternate layers of manure and sod until you have a pile of the desired size. Cover the top of the pile of compost with a thick layer of earth and fix it so that it will shed water. Keep the pile moist, so that there will be no loss of plant food.

When you desire to use any of the compost in an experiment, mix it well and screen out all of the coarse material. Compost not only contains a great deal of plant food, but this plant food has been saved and made available. The sod used in the compost not only furnishes some organic matter, but the soil absorbs and saves the ammonia that is set free by decay. Ammonia is the form of nitrogen that is very valuable as a fertilizer. It is therefore very expensive. It makes plants green and vigorous.

EXPERIMENT 47.

PHYSICAL AND CHEMICAL CHANGES.

All substances in nature undergo changes either physical or chemical. Students should know the difference between these two classes of changes, and the following experiment will make this difference clear. Any change of a substance which merely changes its form without changing its composition is said to be a physical change. Any change which affects the composition of a substance is said to be a chemical change. When water freezes or changes to steam it is still water, and there has been no change except in the form of the substance. But when coal burns, the material has been changed and we no longer have coal but entirely new products with different compositions. The change in the water has been a physical change, while the change in the coal has been a chemical change.

Place some sulphur in a dish that can be heated. Heat the sulphur until it melts. Now pour the sulphur slowly into a glass vessel of water. Examine it and note any changes that it may have undergone. Lay it aside for a few days and examine again. Have the changes which the sulphur has undergone been chemical or physical? Explain your answer.

Put a piece of quicklime in a dish of water. After the action of the lime ceases, examine it. Is there any change? Lay it aside and after a few days examine it again. Has the change been permanent? Has the change been physical or chemical? If chemical, what is the new substance?

EXPERIMENT 48.

THE HOTBED AS A SCHOOL PROBLEM.

In connection with the school work in soils, the hotbed can be used to a great advantage. In fact, in the ordinary school, where school is dismissed during all of the warm months of the year, the best solution of the school garden problem seems to be the hotbed. In a hotbed work can progress regardless of weather conditions outside, and real soil problems can be demonstrated in both the late fall and early spring months.

A hotbed may vary in size, but six feet wide and from six to twelve feet long makes a desirable size. Since it must be covered with window sash, it is well to obtain the sash first and then make the hotbed to fit the sash. The hotbed should be located on the south side of a building and the north side of the frame should be the higher. By slanting the frame to the south more light and heat is enabled to pass through than if it were level. The ground on which the hotbed is placed should be high or well drained.

In constructing the hotbed a pit must be made and filled with fresh manure which has been allowed to heat for about a week. This manure furnishes the heat to the growing plant. The pit should be from two to two and one-half feet in depth, and should be filled within four inches of the top with manure, well firmed. The surface four inches inside the hotbed should be composed of rich loam soil or well decayed compost. The compost is to be preferred if it can be obtained.

Many plants can be started in the early spring in such a bed; they can thus be cared for by the students while school is in session. Later, when school is out, they can take these plants home and transplant them to their gardens. Here the interest aroused in a school project will be carried to completion in the production of mature plants.

The hotbed can be set in the fall and plants such as radishes and lettuce can be grown to maturity. By this means a school may practice gardening until January, and from March until late spring. The hotbed is worth while in either a course in soils or crops. All details should be understood before the work is attempted. No school is completely equipped to teach the above subjects without a hotbed.

EXPERIMENT 49.

NITROGEN IN PLANTS.

Students have to take the statement for granted that there is nitrogen in plants, and that nitrogen is the most important plant food. The following experiment will show that there is really nitrogen in plants and that it can be removed. Nitrogen can be made to leave a plant in the form of ammonia. Ammonia is a compound of hydrogen and nitrogen. Ammonia is a base and will turn red litmus paper blue. The odor of ammonia is characteristic and can be easily recognized.

To show that a plant contains nitrogen, grind a small amount of some roughage (as hay) in a food chopper. Mix this material with an equal amount of strong potassium hydroxide. Place the entire mass in a small-mouth bottle which you can heat. Suspend a strip of red litmus paper in the mouth of the bottle. Heat the solution gently until it boils. If there is any nitrogen present in the plant it will be given off in the form of ammonia, and will turn red litmus blue. Notice the odor given off. Is there sufficient nitrogen present to be readily determined?

EXPERIMENT 50.

THE VALUE OF A MULCH.

If you do not have a pair of balances in the laboratory to perform experiment number 26, you may show the value of a mulch as follows: Bore a hole in the middle of a yardstick or any stick near the same size. Then suspend the yardstick on a nail driven in the edge of a table. Fill two cans with fine loam soil and saturate each with water. After they are dry enough to work, remove an inch of soil from one can and replace with any desired kind of a mulch. Hang one can of soil on each end of the yardstick by means of string or wire. Move the cans along the yardstick until they exactly balance one another. Leave alone and observe any change. Which can becomes the lighter? Why? How long does it take to produce any decided change in the weight of the two cans?

EXPERIMENT 50.

AN EXCURSION.

There is nothing more valuable than an occasional trip to the farm with the class to observe real existing conditions. Give complete instructions to a class before starting and do not give the trip the air of a pleasure party, or picnic. In a note-book which he should take along for that purpose have each pupil write about the things of interest and value which he sees.

The teacher should, if possible, make the trip before the excursion is attempted by the entire class. This will give the teacher material from which to talk and will make the trip valuable from start to finish.

Study the growing crops. Can you find one field of some crop that looks better than another field which has the same crop? How do you account for the difference? Compare the amount of growth in different kinds of crops. Decide which fields are the best for corn and why. Notice the amount of ground that is not producing anything for the farmer. Suggest ways that he might use this waste land. Notice the kind of plants that grow best in poor soil. Compare, if you can, a field that is drained with one that is not drained. Notice parts of a field that have had commercial fertilizer applied to them, and compare with other fields that have not been fertilized. The farmer will be glad to tell you where he has applied fertilizer if you will ask him. Make a list of all of the useful plants that are growing on the farm. Make a list of all of the harmful plants that you have seen and can name. Many interesting conditions can be discovered at various times during the year, and excursions to determine definite things should often be made. These excursions should include not only the field, and soil study, but should go into the industries carried on near the school.

EXPERIMENT 52.

THE EFFECT OF FIRMING THE SOIL ON THE GERMINATION OF SEEDS.

Object. The simple act of pressing soil about seeds on planting them has ofttimes saved a valuable seeding that would otherwise have been lost. To prove the benefit of firming the soil on the time of the germination of seeds perform the following experiment:

Apparatus. A large, shallow box filled with soil, or a plot of ground out of doors; some seeds of any common kind, and a small board.

Procedure. After making the soil very loose, plant some seeds in the box of soil or in the plot out of doors. Then with the small board pack the soil very firmly around the seeds in one-half of the bed. Leave the soil as loose as possible around the remainder. Water carefully and regularly until the seeds come up. Where do the seeds come up first? Record the results of this experiment at the close of the fourth day; at the end of the sixth day, and at the end of the eighth day. What is the value of rolling a loose soil after planting the seed? After the seeds have sprouted, should the soil be left firm or should it be loosened? Why?